Amendments to the Claims

1. (Original) A process for forming a copper interconnect in a substrate including a connect hole vertically extending through an inter-level dielectric layer, comprising the steps of:

a first step, performed at least partially by atomic layer epitaxy, of depositing a barrier layer comprising tantalum on sides of said hole;

a second step, performed by physical vapor deposition, of depositing a copper seed layer over said barrier layer; and

filling by electrochemical plating copper into said hole over said copper seed layer.

- 2. (Original) The process of Claim 1, wherein said barrier layer comprises tantalum nitride.
- 3. (Original) The process of Claim 1, further comprising a third step performed between said first and second steps of etching said barrier layer at the bottom of said hole.
- 4. (Original) The process of Claim 3, wherein third step includes generating an argon plasma and biasing a pedestal electrode supporting said substrate to attract argon ions to said substrate, thereby etching said barrier layer.
- 5. (Original) The process of Claim 4, wherein said generating step includes inductively coupling RF power into a plasma reactor containing said pedestal electrode.
- 6. (Original) The process of Claim 1, wherein said first step includes an initial CVD step for depositing a first part of said barrier layer and a subsequent sputtering step for depositing a second part of said barrier layer.

7. (Original) A process for forming a copper interconnect in a substrate including a connect hole vertically extending through an inter-level dielectric layer, comprising the sequentially performed steps of:

a first step, performed by chemical vapor deposition, of depositing a first barrier layer comprising tantalum on sides of said hole;

a second step, performed by sputtering, of depositing a second barrier layer comprising tantalum on said sides of said hole;

a third step, performed by physical vapor deposition, of depositing a copper seed layer over said first and second barrier layers; and

a fourth step, performed by electrochemical plating, of filling copper into said hole over said copper seed layer.

- 8. (Original) The process of Claim 7, wherein said chemical vapor deposition comprises atomic layer epitaxy.
- 9. (Original) The process of Claim 7, further comprising a fifth step performed after said first step performed in a sputter reactor of etching said first barrier layer at the bottom of said hole.
- 10. (Original) The process of Claim 9, wherein fifth step includes generating an argon plasma and biasing a pedestal electrode supporting said substrate to attract argon ions to said substrate, thereby etching said barrier layer.
- 11. (Original) The process of Claim 10, wherein said generating step includes inductively coupling RF power into a plasma reactor containing said pedestal electrode.
- 12. (Original) The process of Claim 7, wherein said chemical vapor deposition comprises atomic layer epitaxy.

13. (Original) A process for forming a copper interconnect in a substrate including a connect hole vertically extending through an inter-level dielectric layer, comprising the steps of:

depositing by a deposition process comprising chemical vapor deposition a nitrided barrier layer on sides of said hole;

in a sputter reactor including a tantalum target, etching said nitrided barrier layer on a bottom of said hole;

in said sputter reactor, depositing a material comprising tantalum on sidewalls of said hole to form a second barrier layer;

depositing by physical vapor deposition a copper seed layer over said second barrier layer; and

filling by electrochemical plating copper into said hole over said copper seed layer.

- 14. (Original) The process of Claim 13, wherein said deposition process comprises atomic layer deposition.
- 15. (Original) The process of Claim 13, wherein said nitrided barrier layer comprises TiSiN.
- 16. (Original) The process of Claim 13, wherein said second barrier layer comprises TaN.
- 17. (New) A method of filling one or more of a via and a trench in a patterned substrate, comprising:
- a) depositing a generally conformal first barrier layer in one or more of the via and the trench on the patterned sbustrate by chemical vapor deposition, wherein the first barrier layer comprises a silicided nitride of a refractory metal selected from the group consisting of Ti, Ta, and W;
 - b) removing the first barrier layer from horizontal surfaces of the patterned substrate;

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- c) depositing a second barrier layer by physical vapor deposition; and
- d) then depositing one or more conductive materials.
- 18. (New) The method of Claim 1, wherein depositing the conductive material comprises depositing a seed layer and a metal layer in the via and/or the trench after the second barrier layer is deposited.
- 19. (New) The method of Claim 18, wherein the first barrier layer comprises a material is selected from the group consisting of Ti, Ta, W, and nitrides thereof.
- 20. (New) The method of Claim 1, wherein the second barrier layer comprises at least one refractory metal selected from the group consisting of Ta and W.
 - 21. (New) The method of Claim 18, wherein the seed layer comprises copper.
 - 22. (New) The method of Claim 21, wherein the metal layer comprises is copper.
- 23. (New) The method of Claim 17, wherein the first barrier layer is deposited and removed from horizontal surfaces of the patterned substrate within a single chamber of an integrated processing tool.
- 24. (New) The method of Claim 23, wherein the chamber is a chemical vapor deposition chamber and the first barrier layer is deposited and etched in a sputter chamber.
- 25. (New) The method of Claim 18, wherein the seed layer is deposited by physical vapor deposition.
 - 26. (New) The method of Claim 18, wherein the metal layer is deposited by chemical

vapor deposition.

- 27. (New) The method of Claim 18, wherein the metal layer is deposited by electroplating.
- 28. (New) The method of Claim 17, wherein the second barrier layer comprises a material selected from the group consisting of Ta, TaN, W, WN, Ti, and TiN, and wherein the second barrier layer has a thickness of from about 2nm to about 5nm at the bottom of the via.
 - 29. (New) A method of filling one or more holes in a patterned substrate, comprising:
- a) depositing a generally conformal first barrier layer on the patterned substrate by atomic layer deposition;
 - b) removing the first barrier layer from horizontal surfaces of the patterned substrate;
 - c) depositing a second barrier layer by physical vapor deposition; and
 - d) then depositing one or more conductive materials to fill the holes.
- 30. (New) The method of Claim 29, wherein depositing the conductive material comprises depositing a seed layer and a metal layer in the holes after the second barrier layer is deposited.
- 31. (New) The method of Claim 30, wherein the first barrier layer comprises a material selected from the group consisting of Ta, TaN, W, and WN.
- 32. (New) The method of Claim 31, wherein the second barrier layer comprises a material selected from the group consisting of Ta, TaN, T, TiN, W, and WN.
 - 33. (New) The method of Claim 32, wherein the seed layer comprises copper.

- 34. (New) The method of Claim 33, wherein the metal layer comprises copper.
- 35. (New) The method of Claim 30, wherein the seed layer is deposited by physical vapor deposition.
- 36. (New) The method of Claim 30, wherein the metal layer is deposited by electroplating.
- 37. (New) The method of Claim 29, wherein the second barrier layer comprises a material selected from the group consisting of Ta, TaN, W, WN, Ti, and TiN.
- 38. (New) A method of filling one or more of a via and a trench in a patterned substrate, comprising:
- a) depositing a generally conformal first barrier layer on the patterned substrate by chemical vapor deposition;
 - b) removing the first barrier layer from the horizontal surfaces of the patterned substrate;
 - c) depositing a second barrier layer by physical vapor deposition; and
 - d) then depositing one or more conductive materials.
- 39. (New) The method of Claim 38, wherein depositing the conductive material comprises depositing a seed layer and a metal layer in the via and/or the trench after the second barrier layer is deposited.
- 40. (New) A method of filling one or more of a via and a trench in a patterned substrate having a metal layer underlying the via, comprising:
- a) depositing a generally conformal first barrier layer on the patterned substrate by chemical vapor deposition, wherein the first barrier layer comprises a silicided nitride of a refractory metal selected from the group consisting of Ti, Ta, and W;

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- b) removing the first barrier layer from horizontal surfaces of the patterned substrate;
- c) depositing by physical vapor deposition a second barrier layer sufficient to provide a barrier on the bottom of the trench; and
 - d) then depositing one or more conductive materials.
- 41. (New) A method of filling one or more of a via and a trench in a patterned substrate having a metal layer underlying the via, comprising:
- a) depositing a generally conformal first barrier layer on the patterned substrate by atomic layer deposition;
 - b) removing the first barrier layer from horizontal surfaces of the patterned substrate;
- c) depositing by physical vapor deposition a second barrier layer sufficient to provide a barrier on a bottom of the trench; and
 - d) then depositing one or more conductive materials.